WATER RESOURCES RESEARCH

A JOURNAL OF THE SCIENCES OF WATER

VOLUME 3, 1967

PUBLISHED QUARTERLY BY THE AMERICAN GEOPHYSICAL UNION

WATER RESOURCES RESEARCH

TABLE OF CONTENTS, VOLUME 3, 1967

First Quarter

The Role of Universities in Water Resources Education: The Social Sciences MAYNARD M. HUFSCHMIDT 3

Similarities between Flood Control Problems and Other Aspects of Water Management in the United States WILLIAM R. WALKER 11

The Impact of Price on Residential Water Demand and Its Relation to System Design and Price Structure CHARLES W. HOWE AND F. P. LINAWEAVER 13

A Socially Optimum Pricing Policy for a Public Water Agency GARDNER BROWN, JR., AND C. B. MCGUIRE 33

Temporal Allocation of Groundwater OSCAR R. BURT 45

Viewing Water Renovation and Reuse in Regional Water Resources Systems RICHARD J. FRANKEL 57

Recreation Benefits from Water Pollution Control: A Further Note on Benefit Evaluation JOE B. STEVENS 63

The Temporal and Spatial Distribution of Dissolved Oxygen in Streams DONALD J. O'CONNOR 65

The Growth and Development of Attached Stream Bacteria, Part 1. Theoretical Growth Kinetics of Attached Stream Bacteria WALTER M. SANDERS III 81

Stratification of Fresh and Salt Water on Barrier Islands as a Result of Differences in Sediment Permeability WILLIAM H. HARRIS 89

Retention of ^{65}Zn by Columbia River Sediment VERNON JOHNSON, NORMAN CUTSHALL, AND CHARLES OSTERBERG 99

On the Topology of River Nets A. E. SCHEIDEGGER 103

Measurement of Hydraulic and Sediment Transport Variables in a Small Recirculating Flume R. E. RATHBUN AND H. P. GUY 107

Effects of Climatologic and Basin Characteristics on Annual Runoff SEPPO E. MUSTONEN 123

Rainfall Intensity and Elevation in Southwestern Idaho CHARLES F. COOPER 131

Runoff and Hillslope Erosion Resulting from a High-Intensity Thunderstorm near Mack, Western Colorado RICHARD F. HADLEY AND GREGG C. LUSBY 139

Infiltration, Overland Flow, and Soil Movement on Frozen and Snow-Covered Plots HAROLD F. HAUPT 145

Relationship between Precipitation, Evaporation, and Runoff in Tropical-Equatorial Regions S. SOLOMON 163

Effects of a Monolayer on Reservoir Temperature and Evaporation JON F. BARTHOLIC, JACK R. RUNKLES, AND ERNEST B. STENMARK 173

Evaporation from Large Deep Lakes FRED I. MORTON 181

A Note Concerning the Eddy Transfer Coefficients of Momentum and Water Vapor under Near-Adiabatic Conditions G. EARL HARBECK, JR. 201

Pontacyl Brilliant Pink as a Tracer Dye in the Movement of Water in Phreatophytes T. W. ROBINSON AND DONALD DONALDSON 203

Some Comments on the Use of Factor Analyses N. C. MATALAS AND BARBARA J. REIHER 213

Average Probability of Extreme Events MANUEL A. BENSON 225

Growth and Decay of Groundwater-Mounds in Response to Uniform Percolation MAHDI S. HANTUSH 227

Depletion of Flow in Right-Angle Stream Bends by Steady Wells MAHDI S. HANTUSH 235

Drawdown in a Well of Large Diameter ISTAVROS S. PAPADOPULOS AND HILTON H. COOPER, JR. 241

The Measurement of Entrapped Gas in the Study of Unsaturated Flow Phenomena LOUIS W. DEBACKER 245

Carbon 14 Ages and Flow Rates of Water in Carrizo Sand, Atascosa County, Texas F. J. PEARSON, JR., AND D. E. WHITE 251

Response of a Finite-Diameter Well to an Instantaneous Charge of Water HILTON H. COOPER, JR., JOHN D. BREDEHOEFT, AND ISTAVROS S. PAPADOPULOS 263

Thermal Influence on Flow from a Compressible Porous Medium ROBERT E. PAASWELL 271

Water Resources Commentary

Urban and Basin Planning DONALD F. WOOD 279

Observations on Title II, Water Resources Planning Act HORACE P. MORGAN 283

Letters:

Bribes and Charges: Some Comments A. MYRICK FREEMAN III 287

Correction 289

Second Quarter

A Study in the Economics of Water Quality Management EDWIN L. JOHNSON 291

Water in West Pakistan GUTHRIE S. BIRKHEAD 307

Six Federal Reclamation Projects and the Distribution of Income A. MYRICK FREEMAN, III 319

Economic Analysis of Alternative Flood Control Measures L. DOUGLAS JAMES 333

Flood Control Alternatives and the Economics of Flood Protection ROBERT C. LIND 345

Some Error Properties of Segmented Hydrologic Functions WILLARD M. SNYDER 359

When Is It Safe To Extend a Prediction Equation?—An Answer Based Upon Factor and Discriminant Function Analysis JAMES R. WALLIS 375

A Laplace Transform Proof of the Theorem of Moments for the Instantaneous Unit Hydrograph M. H. DISKIN 385

Regression Models for Predicting On-Site Runoff from Short-Duration Convective Storms H. A. SCHREIBER AND D. R. KINCAID 389

Forecasting the Levels of the Great Lakes B. G. DECOOKE AND E. MEGERIAN 397

Experience with the Pressure Pillow as a Snow Measuring Device V. E. PENTON AND A. C. ROBERTSON 405

Snow Accumulation in a Manzanita Brush Field in the Sierra Nevada GENE C. WILKEN 409

Control Levels for Quantitative Evaluation of Weather Modification Attainments RADMILO D. MARKOVIC 423

A Simple Evaporimeter for Use in Cold Areas J. C. WILCOX 433

High Alcohols as Antitranspirants J. GALE, EDWIN B. ROBERTS, AND ROBERT M. HAGAN 437

The Effect of Applied Interception on Transpiration Rates of Potted Ponderosa Pine DAVID B. THORUD 443

Effects of Construction on Fluvial Sediment, Urban and Suburban Areas of Maryland M. GORDON WOLMAN AND ASHER P. SCHICK 451

Hydraulic and Micromorphological Properties of Stream Channel Sediments H. K. QASHU AND S. W. BUOL 465

Slope Length of Claypan Soil Affects Runoff V. C. JAMISON AND D. B. PETERS 471

Accuracy of Discrete Models Used To Predict Estuary Pollution J. V. LEEDS 481

Hydrologic Data Collection in Tidal Estuaries CHARLES G. GUNNERSON 491

Applications of Factor Analysis in Study of Chemistry of Groundwater Quality, Mojave River Valley, California D. R. DAWDY AND J. H. FETH 505

The Determination of the Ionization Constant of 2, 4-D in Water R. L. WERSHAW, M. C. GOLDBERG, AND D. J. PINCKNEY 511

The Persistence of Silvex in Water and Hydrosoil D. R. COCHRANE, J. D. POPE, JR., H. P. NICHOLSON, AND G. W. BAILEY 517

Insecticides in Tile Drainage Effluent WILLIAM R. JOHNSTON, F. T. ITTIHADIEH, KENNETH R. CRAIG, AND ARTHUR F. PILLSBURY 525

Infiltration in Sands and Its Relation to Groundwater Recharge W. O. SMITH 539

Numerical Solutions for Dispersion in Porous Mediums URI Y. SHAMIR AND DONALD R. F. HARLEMAN 557

Flow of Groundwater in Relatively Thick Leaky Aquifers MAHDI S. HANTUSH 583

Use of Thermal Model To Investigate the Theory of Transient Flow to a Partially Penetrating Well I. JAVANDEL AND P. A. WITHERSPOON 591

On the Meaning of the Dupuit and Pavlovskii Approximations in Aquifer Flow S. IRMAY 599

Explanation of Paradoxes in Dupuit-Forchheimer Seepage Theory DON KIRKHAM 609

Theoretical Analysis of Regional Groundwater Flow. 2. Effect of Water-Table Configuration and Subsurface Permeability Variation R. ALLAN FREEZE AND P. A. WITHERSPOON 623

Letters

Note on 'The Accuracy of the Prediction of Floods of High Return Period' J. E. NASH AND J. AMOROCHO 635

Design Philosophy, Specifications, and Implications of 'Hydro,' a Pilot Computer Language for Hydrology and Hydraulic Engineering G. BUGLIARELLO, W. D. MCNALLY, J. T. GORMLEY, AND J. T. ONSTOTT 636

Excess Benefit GORDON TULLOCK 643

Third Quarter

An Optimization Method for Branching Multistage Water Resource Systems W. L. MEIER, JR., AND C. S. BEIGHTLER 645

An Extension to the Thomas-Fiering Model for the Sequential Generation of Streamflow ARCHIE A. HARMS AND THOMAS H. CAMPBELL 653

Mean Range of Linearly Dependent Normal Variables with Application to Storage Problems VUJICA YEVJEVICH 663

Groundwater Management under Quadratic Criterion Functions OSCAR R. BURT 673

Investigation of the Technical Feasibility of Storing Fresh Water in Saline Aquifers OMAR J. ESMAIL AND OSCAR K. KIMBLER 683

Determination of the Hydraulic Conductivity of Unsaturated Soils from an Analysis of Transient Flow Data GEORGES VACHAUD 697

Relations between Topography and Annual Precipitation in Western Oregon and Washington VAIL P. SCHERMERHORN 707

Meteorological Studies in the Marmot Creek Watershed, Alberta, Canada, in August 1965 R. E. MUNN AND D. STORR 713

Interception by Eastern White Pine J. D. HELVEY 723

Throughfall and Stemflow in a Pine-Hardwood Stand in the Ouachita Mountains of Arkansas EDWIN R. LAWSON 731

The Hydrologic Importance of Transpiration Control by Stomata RICHARD LEE 737

Unsteady, One-Dimensional Flow over a Plane—The Rising Hydrograph D. A. WOOLHISER AND J. H. LIGGETT 753

A Comment on Horton's Law of Stream Numbers J. SAMUEL SMART 773

Sediment Transport of Streams in the Washita River Basin in Caddo and Grady Counties, Oklahoma P. B. ALLEN AND N. H. WELCH 777

Erodibility Indices for Wildland Soils of Oahu, Hawaii, as Related to Soil Forming Factors TERUO YAMAMOTO AND HENRY W. ANDERSON 785

Recovery of Bacterial Pathogens from High Quality Surface Water J. F. FAIR AND S. M. MORRISON 799

SYMPOSIUM ON ANALYTICAL METHODS IN HYDROLOGY 805

Prologue 807

Optimization Techniques for Hydrologic Engineering LEO R. BEARD 809

Time Series Analysis N. C. MATALAS 817

Variance Spectrum Analysis PAUL R. JULIAN 831

Finite Differencing Methods D. L. BRAKENSIEK 847

The Nonlinear Prediction Problem in the Study of the Hydrologic Cycle J. AMOROCHO 861

A Review of Rainfall-Runoff Physical Models as Developed by Dimensional Analysis and Other Methods D. L. CHERY, JR. 881

Linear Analysis of Hydrographs WILLIAM D. MITCHELL 891

Analyzing Subsurface Flow Systems with Electric Analogs HERMAN BOUWER 897

Letters:

Comments on Paper by G. E. Harbeck, Jr., 'A Note Concerning the Eddy Transfer Coefficients of Momentum and Water Vapor under Near-Adiabatic Conditions' J. W. DEARDORFF 909

Reply G. E. HARBECK, JR. 911

Fourth Quarter

Simulation of a National Flood Insurance Fund JOHN C. SCHAAKE, JR., AND MYRON B FIERING 913

Synthetic Hydrology Based on Regional Statistical Parameters M. A. BENSON AND N. C. MATALAS 931

Mathematical Assessment of Synthetic Hydrology N. C. MATALAS 937

Simplified versus Optimum Unit Hydrographs—One Comparison WILLARD M. SNYDER 947

The Dynamics of Public Roles in the Selection of Revenue Sources in Local Water Administration CHARLES L. GARRISON AND DUANE W. HILL 949

The Relation between Mainstream Length and Area in Drainage Basins J. S. SMART AND A. J. SURKAN 963

Estimating Incident Terrestrial Radiation under All Atmospheric Conditions E. A. ANDERSON AND D. R. BAKER 975

Lysimeter and Watershed Evapotranspiration SEPPO E. MUSTONEN AND J. L. MCGUINNESS 989

Generalized Estimates of Free-Water Evaporation M. A. KOHLER AND L. H. PARMELE 997

Time Distribution of Rainfall in Heavy Storms F. A. HUFF 1007

Optimum Density of Rainfall Networks P. S. EAGLESON 1021

Snow Catch by Conifer Crowns DONALD R. SATTERLUND AND HAROLD F. HAUPT 1035

A Thermodynamic Analogy for Meander Systems A. E. SCHEIDEGGER 1041

Analysis of Nonlinearities in Ground Water Hydrology: A Hybrid Computer Approach VENKATESWARARAO VEMURI AND JOHN A. DRACUP 1047

A Method of Determining the Permeability and Effective Porosity of Unconfined Anisotropic Aquifers G. DAGAN 1059

A Sensor for Water Flux in Soil. "Point Source" Instrument G. F. BYRNE, J. E. DRUMMOND, AND C. W. ROSE 1073

On the Similitude of Dispersion Phenomena in Homogeneous and Isotropic Porous Mediums Y. BACHMAT 1079

Letters:

Water Quality as Affected by a Wyoming Mountain Bog DAVID L. STURGES 1085

Surface Chloride Distribution in Maine Lakes DONALD F. MAIRS 1090

Note on 'A New Approach for Estimating Transmissibility from Specific Capacity' by R. Theodore Hurr T. N. NARASIMHAN 1093

Reply R. THEODORE HURR 1095

INDEX OF AUTHORS

Allen, P. B. 777
Amorocho, J. 635, 861
Anderson, E. A. 975
Anderson, Henry W. 785

Bachmat, Y. 1079
Bailey, G. W. 517
Baker, D. R. 975
Bartholic, Jon F. 173
Beard, Leo R. 809
Beightler, C. S. 645
Benson, M. A. 225, 931
Birkhead, Guthrie S. 307
Bouwer, Herman 897
Brakensiek, D. L. 847
Bredehoeft, John D. 263
Brown, Gardner, Jr. 33
Bugliarello, G. 636
Buol, S. W. 465
Burt, Oscar R. 45, 673
Byrne, G. F. 1073

Campbell, Thomas H. 653
Chery, D. L., Jr. 881
Cochrane, D. R. 517
Cooper, Charles F. 131
Cooper, Hilton H., Jr. 241, 263
Craig, Kenneth R. 525
Cutshall, Norman 99

Dagan, G. 1059
Dawdy, D. R. 505
Deardorff, J. W. 909
DeBacker, Louis W. 245
DeCooke, B. G. 397
Diskin, M. H. 385
Donaldson, Donald 203
Dracup, John A. 1047
Drummond, J. E. 1073

Eagleson, P. S. 1021
Esmail, Omar J. 683

Fair, J. F. 799
Feth, J. H. 505
Fiering, Myron B 913
Frankel, Richard J. 57
Freeman, A. Myrick, III 287, 319
Freeze, R. Allan 623

Gale, J. 437
Garrison, Charles L. 949
Goldberg, M. C. 511
Gormley, J. T. 636
Gunnerson, Charles G. 491
Guy, H. P. 107

Hadley, Richard F. 139
Hagan, Robert M. 437
Hantush, Madhi S. 227, 235, 583
Harbeck, G. Earl, Jr. 201, 909, 911
Harleman, Donald R. F. 557
Harms, Archie A. 653
Harris, William H. 89
Haupt, Harold F. 145, 1035
Helvey, J. D. 723
Hill, Duane W. 949
Howe, Charles W. 13
Huff, F. A. 1007
Hufschmidt, Maynard M. 3
Hurr, R. Theodore 1095

Irmay, S. 599
Ittihadieh, F. T. 525

James, L. Douglas 333
Jamison, V. C. 471
Javandel, I. 591
Johnson, Edwin L. 291
Johnson, Vernon 99
Johnston, William R. 525
Julian, Paul R. 831

Kimbler, Oscar K. 683
Kincaid, D. R. 389
Kirkham, Don 609
Kohler, M. A. 997

Lawson, Edwin R. 731
Lee, Richard 737
Leeds, J. V. 481
Liggett, J. H. 753
Linaweaver, F. P., Jr. 13
Lind, Robert C. 345
Lusby, Gregg C. 139

Mairs, Donald F. 1090
Markovic, Radmilo D. 423
Matalas, N. C. 213, 817, 931, 937
McGuinness, J. L. 989
McGuire, C. B. 33
McNally, W. D. 636
Megerian, E. 397
Meier, W. L., Jr. 645
Mitchell, William D. 891
Morgan, Horace P. 283
Morrison, S. M. 799
Morton, Fred I. 181
Munn, R. E. 713
Mustonen, Seppo E. 123, 989

Narasimhan, T. N. 1093
Nash, J. E. 635
Nicholson, H. P. 517

O'Connor, Donald J. 65
Onstott, J. T. 636
Osterberg, Charles 99

Paaswell, Robert E. 271
Papadopulos, Istavros S. 241, 263
Parmele, L. H. 997
Pearson, F. J., Jr. 251
Penton, V. E. 405
Peters, D. B. 471
Pillsbury, Arthur F. 525
Pinckney, D. J. 511
Pope, J. D., Jr. 517

Qashu, H. K. 465

Rathbun, R. E. 107
Reiher, Barbara J. 213
Roberts, Edwin B. 437
Robertson, A. C. 405
Robinson, T. W. 203
Rose, C. W. 1073
Runkles, Jack R. 173

Sanders, Walter M., III 81
Satterlund, Donald R. 1035
Schaake, John C., Jr. 913
Scheidegger, A. E. 103, 1041
Schermerhorn, Vail P. 707
Schick, Asher P. 451
Schreiber, H. A. 389
Shamir, Uri Y. 557
Smart, J. Samuel 773, 963
Smith, W. O. 539
Snyder, Willard M. 359, 947
Solomon, S. 163
Stenmark, Ernest B. 173
Stevens, Joe B. 63
Storr, D. 713
Sturges, David L. 1085
Surkan, A. J. 963

Thorud, David B. 443
Tullock, Gordon 643

Vachaud, Georges 697
Vemuri, Venkateswararao 1047

Walker, William R. 11
Wallis, James R. 375
Welch, N. H. 777
Wershaw, R. L. 511
White, D. E. 251
Wilcox, J. C. 433
Wilken, Gene C. 409
Witherspoon, P. A. 591, 623
Wolman, M. Gordon 451
Wood, Donald F. 279
Woolhiser, D. A. 753

Yamamoto, Teruo 785
Yevjevich, Vujica 663

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION
(Act of October 23, 1962; Section 4369, Title 39, United States Code)

1. DATE OF FILING
October 13, 1967

2. TITLE OF PUBLICATION
Water Resources Research

3. FREQUENCY OF ISSUE
Quarterly

4. LOCATION OF KNOWN OFFICE OF PUBLICATION *(Street, city, county, state, zip code)*
William Byrd Press, Inc., 2901 Byrdhill Road, Richmond, Virginia 23205

5. LOCATION OF THE HEADQUARTERS OR GENERAL BUSINESS OFFICES OF THE PUBLISHERS *(Not printers)*
2100 Pennsylvania Avenue, N.W., Washington, D. C. 20037

6. NAMES AND ADDRESSES OF PUBLISHER, EDITOR, AND MANAGING EDITOR
PUBLISHER *(Name and address)*
American Geophysical Union, 2100 Pennsylvania Avenue, N.W., Washington, D. C. 20037

EDITOR *(Name and address)*
Mr. Walter B. Langbein, U. S. Geological Survey, Washington, D. C.
Dr. Charles Howe, Resources for the Future, 1755 Massachusetts Ave., N. W., Washington, D. C.

MANAGING EDITOR *(Name and address)*
Mr. Walter B. Langbein (Address same as above)
Dr. Charles Howe (Address same as above)

7. OWNER *(If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 percent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address, as well as that of each individual must be given.)*

NAME	ADDRESS
American Geophysical Union (nonprofit organization)	**2100 Pennsylvania Avenue, N.W., Washington, D. C. 20037**

8. KNOWN BONDHOLDERS, MORTAGAGEES, AND OTHER SECURITY HOLDERS OWNING OR HOLDING 1 PERCENT OR MORE OF TOTAL AMOUNT OF BONDS, MORTGAGES OR OTHER SECURITIES *(If there are none, so state)*
NONE

9. Paragraphs 7 and 8 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner. Names and addresses of individuals who are stockholders of a corporation which itself is a stockholder or holder of bonds, mortgages or other securities of the publishing corporation have been included in paragraphs 7 and 8 when the interests of such individuals are equivalent to 1 percent or more of the total amount of the stock or securities of the publishing corporation.

10. THIS ITEM MUST BE COMPLETED FOR ALL PUBLICATIONS EXCEPT THOSE WHICH DO NOT CARRY ADVERTISING OTHER THAN THE PUBLISHER'S OWN AND WHICH ARE NAMED IN SECTIONS 132.231, 132.232, AND 132.233, POSTAL MANUAL *(Sections 4355a, 4355b, and 4356 of Title 39, United States Code)*

	Average No. Copies Each Issue During Preceding 9 Months	Single Issue Nearest to Filing Date
A. Total No. Copies Printed *(Net Press Run)*	5,240	5,440
B. Paid Circulation 1. Sales Through Dealers and Carriers, Street Vendors and Counter Sales	—	—
2. Mail Subscriptions	3,970	4,031
C. Total Paid Circulation	3,970	4,031
D. Free Distribution *(including samples)* by Mail, Carrier or Other Means	16	16
E. Total Distribution *(Sum of C and D)*	3,986	4,047
F. Office Use, Left-Over, Unaccounted, Spoiled after Printing	1,254	1,393
G. Total *(Sum of E & F—should equal net press run shown in A)*	5,240	5,440

(Signature of editor, publisher, business manager, or owner)
I certify that the statements made by me above are correct and complete.
Waldo E. Smith, Executive Secretary